

Linear Model based Geometry Coding for Lidar Acquired Point Clouds

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Introduction

In this paper, we propose a new geometry coding method for point cloud compression (PCC), where the points can be fitted and represented by straight lines. The encoding of the linear model can be expressed by two parts, including the principle component along the line direction and the offsets from the line. Compact representation and high-efficiency coding methods are presented by encoding the parameters of linear model with appropriate quantization step-sizes (QS). To maximize the coding performance, encoder optimization techniques are employed to find the optimal trade-off between coding bits and errors, involving the Lagrangian multiplier method, where the rate-distortion behavior in terms of QS and multiplier is analyzed. We implement our method on top of the MPEG G-PCC reference software, and the results have shown that the proposed method is effective in coding point clouds with explicit line structures, such as the Lidar acquired data for autonomous driving. About 20% coding gains can be achieved on lossy geometry coding.

Major Contributions

- A new model-based method is proposed for geometry coding, which is a linear model that takes the **explicit line structures as a prior knowledge** to improve the coding efficiency.
- Methods of line detection and refinement and encoder-side techniques are proposed to **achieve rate-distortion optimization**.
- Experimental results have shown that the proposed method is able to achieve **significant gains on geometry coding for the Lidar acquired data**, indicating the effectiveness and potential of the proposed linear model in the related application scenario.

Overall Framework

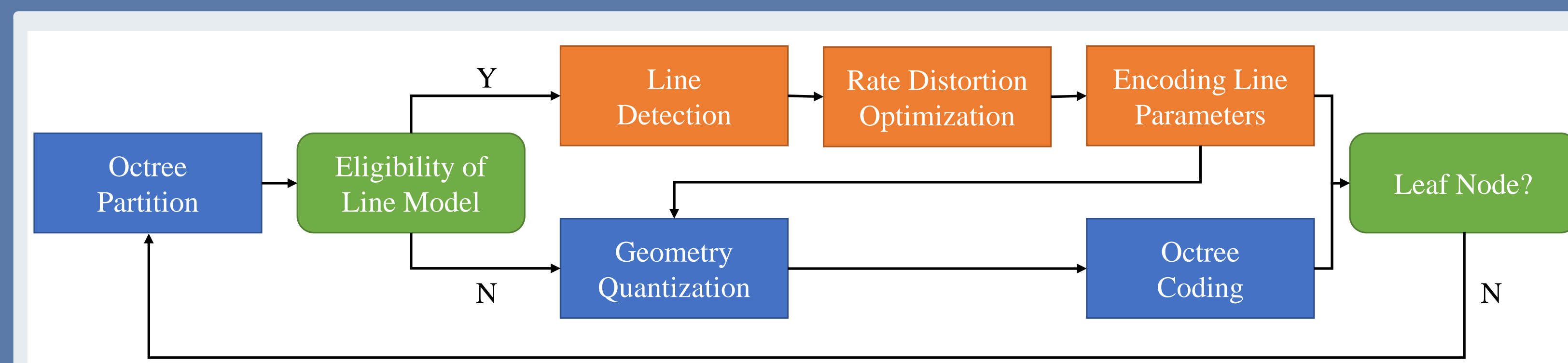


Figure 1: The proposed method is embedded into the octree coding in current G-PCC structure. For each sub-node in the octree, the eligibility of applying linear model is checked first. If it is eligible, the linear model is applied; otherwise, the same octree coding procedure as in current G-PCC is applied. The linear model starts from line detection procedure, in which the potential line candidates are detected from all the points in current sub-node. Subsequently, the line candidates are refined by optimizing the rate-distortion performance. Finally, the points close to the lines are encoded by line parameters. Note that the remaining points in current sub-node that cannot be efficiently represented by the linear model are then encoded by octree coding. The geometry coding ends when all the sub-nodes reach leaf nodes.

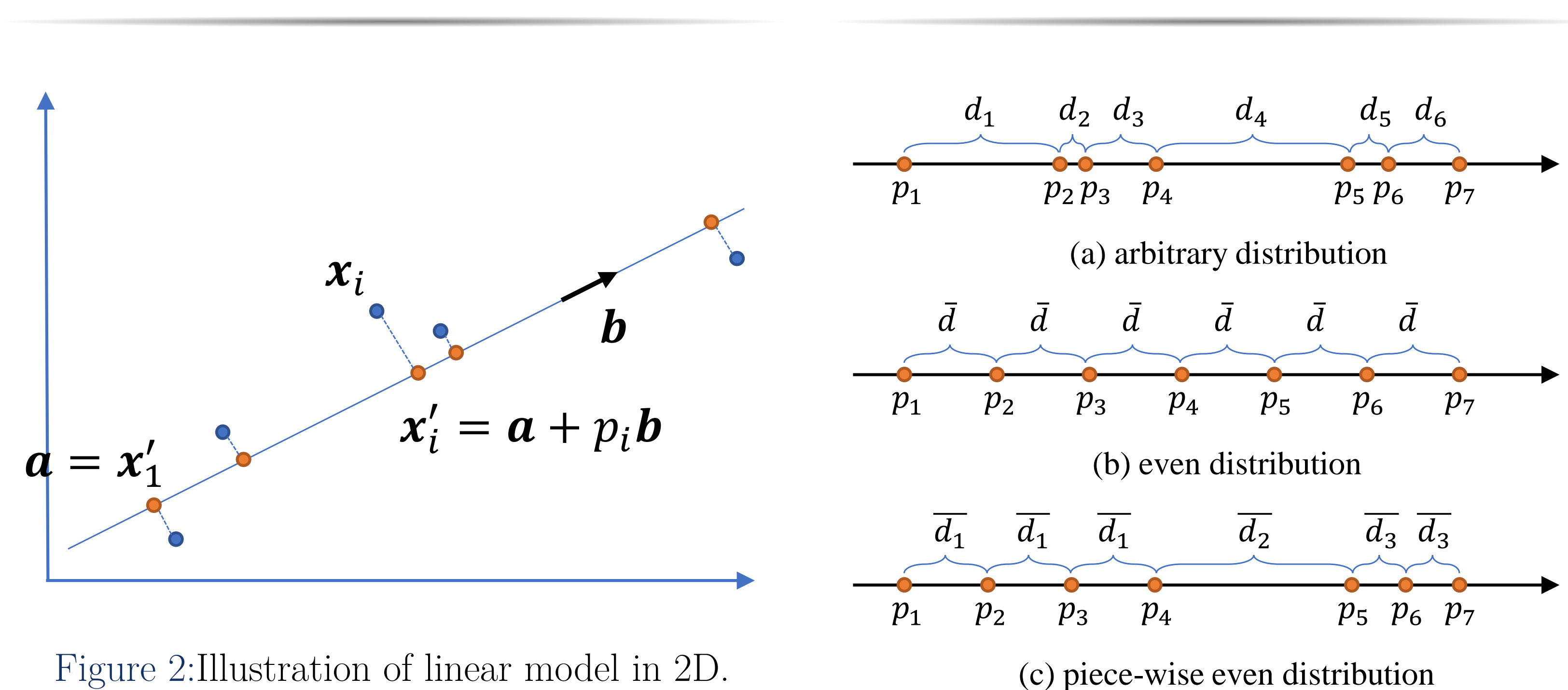
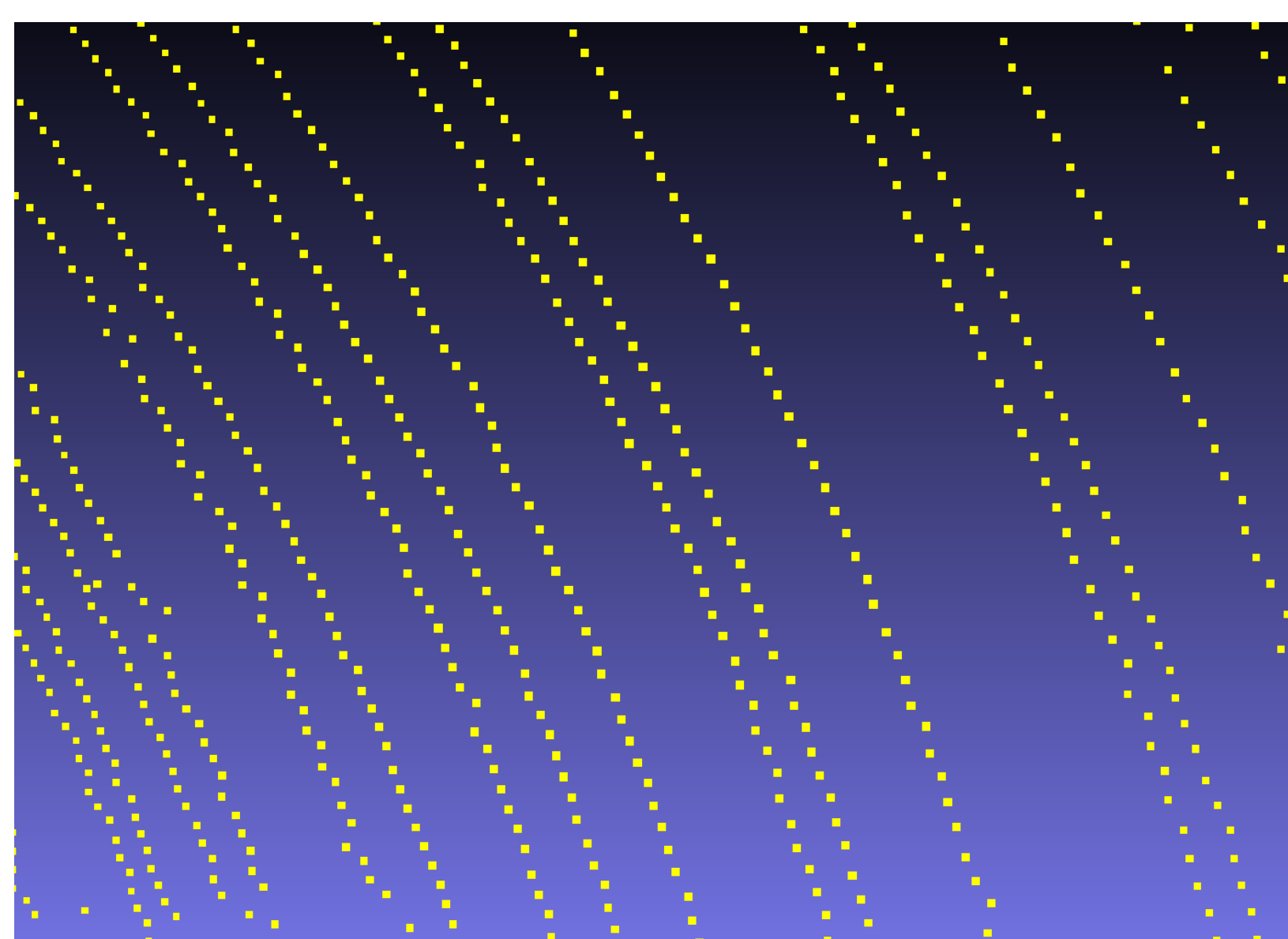


Figure 2: Illustration of linear model in 2D.

RD performance

- Optimal Q_g and λ is fitted by an exponential function, optimal T and λ is fitted by a reciprocal exponential function.
- With the increasing of λ , the optimal Q_g increases and the optimal T decreases monotonously.
- A larger λ indicates the situation that the bitrate is more important than distortion, in which a larger Q_g is applied for achieving lower bitrate and a smaller T estimates a lower RDS of octree coding at low bitrate conditions.

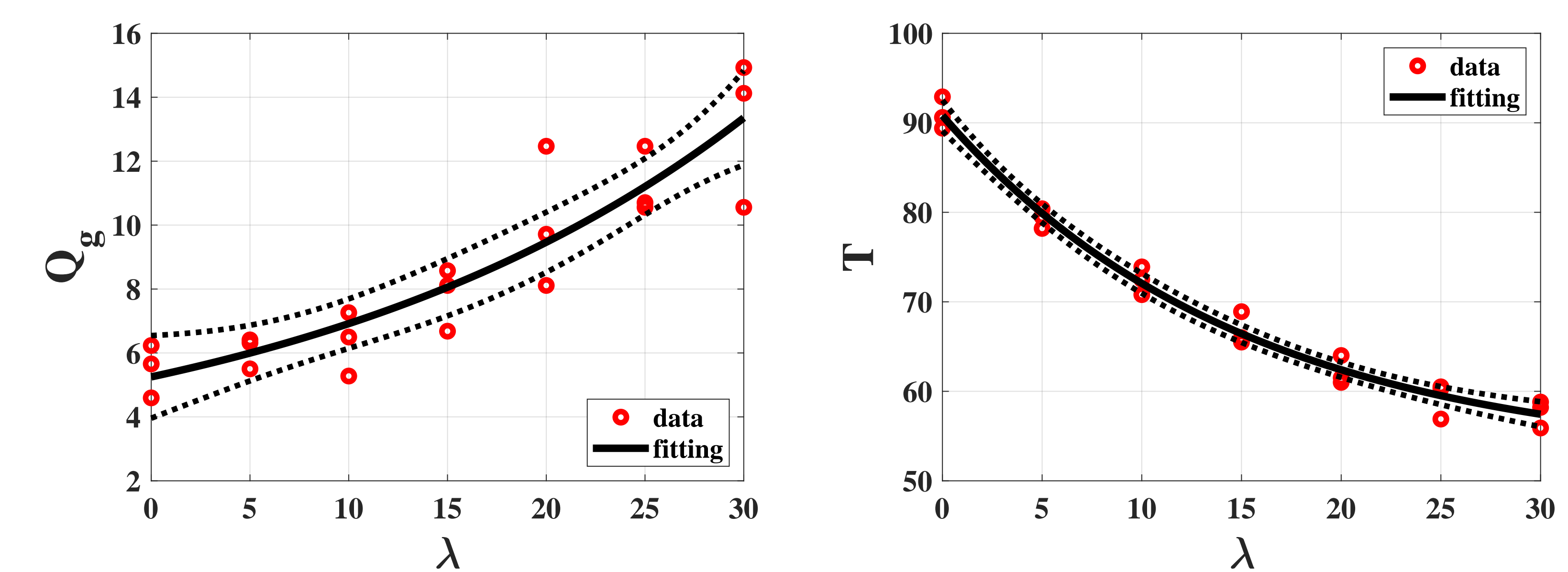


Figure 3: Fitting optimal Q_g and T as functions of λ with 95% confidence bounds.

Experimental Results

We compare the linear model with the TMC13 anchor by BD-rate. It can achieve 4.4% coding gains in terms of D1 and 19.8% coding gains in terms of D2, on average, for the Lidar acquired data.

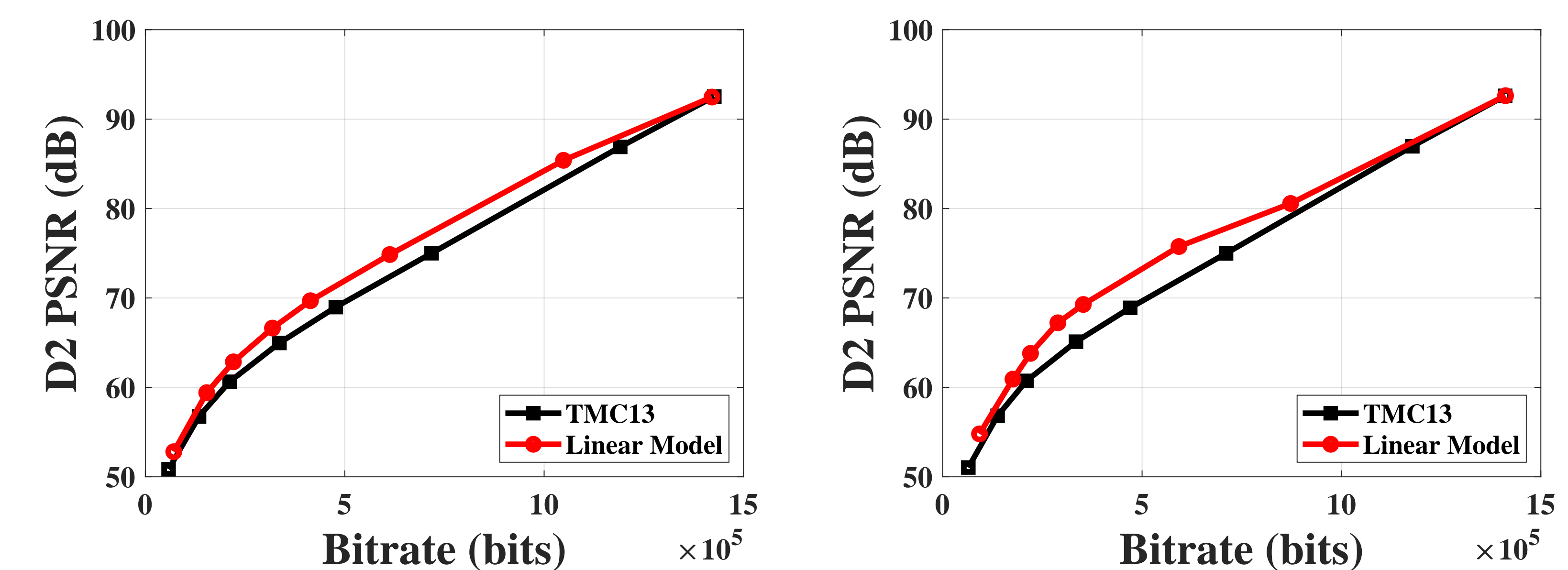


Figure 4: Rate-distortion curves in terms of bitrate and D2 PSNR.

Full-version is available in Arxiv <https://arxiv.org/abs/2001.03871>.